1862MNRAS..22...80A

On the Circularity of the Sun's Disk. By G. B. Airy, Esq., Astronomer Royal.

It has been proposed lately to prepare an apparatus for the purpose of examining whether the Sun's disk is really circular, and, in particular, for ascertaining whether the diameters nearly perpendicular to the ecliptic are equal to those nearly parallel to the ecliptic. I would not by any means discourage the trial of such apparatus, but I would unhesitatingly express my opinion that the result of the trial would be to show whether the apparatus is or is not trustworthy, and not to give any new information regarding the measure of the Sun's diameters in any degree comparable to that which we already possess.

Perhaps few persons except professional astronomers are aware of the enormous amount of evidence which already exists in reference to the values of the Sun's diameters, and of the way in which this evidence is growing every day in the ordinary routine of meridional observations. To make this fully understood, I will here explain what is prepared in the *Nautical Almanac*, what is observed at the Royal Observatory, how the observations are reduced, and how the comparison of the reduced observations with the numbers of the *Nautical Almanac* bears upon the subject now before us.

For the calculations of the *Nautical Almanac*, an assumption is made as to the numerical value of the Sun's diameter, as seen when the Earth is at its mean distance from the Sun. It matters not whether this assumed diameter is or is not correct, provided that it be used consistently in all the calculations of each year; and it matters not whether it be or be not changed from year to year, provided that each volume contain a statement of the assumed diameter which has actually been used in the calculations of that volume. Thus the assumed value of Sun's diameter, as seen at Earth's mean distance, in the *Nautical Almanacs* from 1836 to 1852, was $32' \, 1''.80$; that in the subsequent *Nautical Almanacs* is $32' \, 3''.64$.

With the diameter thus assumed, two sets of numbers are computed in the *Nautical Almanac*. One is, the apparent diameter (or semidiameter) of the Sun at noon on every day; this is found by merely altering the assumed diameter in the inverse proportion of the Earth's varying distance from the Sun. The other is, the duration of passage of the Sun's diameter across the meridian, or the measure of the sidereal time which elapses between the passage of the Sun's western limb and its eastern limb; this is found, from the apparent diameter of the day, by introducing the consideration of the Sun's declination, and of the Sun's motion in right ascension. And, these numbers being prepared, it is evident that we have elements which correspond very closely with facts that may be

1862MNRAS..22...80A

observed, the elements being essentially based on the supposition that the Sun's disk is circular.

Corresponding to these two classes of computed elements, we have two classes of facts observed at the Royal Observatory and at other Observatories. One is, the zenith distance of the Sun's upper limb and that of the Sun's lower limb. When each of these is corrected separately for refraction and parallax, the true results of geocentric observation are obtained; and the difference between them gives the observed *vertical* diameter of the Sun on the day of observation. The other is, the sidereal time shown by the transit-clock at the instant of transit of the Sun's western limb, and that at the transit of the Sun's eastern limb; the difference between these gives the observed duration of passage of the Sun's *horizontal* diameter across the meridian on the day of observation.

Now if we compare each of these numbers separately (namely, the observed vertical diameter and the observed duration of passage of horizontal diameter) with the corresponding numbers in the *Nautical Almanac*, and if we omit consideration of chance-errors of observation, the effect of which may be supposed to be nearly eliminated in the mean of many observations, the following results ought to hold:—If the Sun's disk is really circular, and if the *Nautical Almanac* assumed diameter at mean distance is correct, then the observed vertical diameter will agree with the *Nautical Almanac* diameter for the day, and the observed duration of passage will agree with that of the *Nautical Almanac*. If the Sun's disk is really circular, but the assumed diameter incorrect, then neither of the compared measures will agree with the corresponding computation of the *Nautical Almanac;* each discordance (one of vertical diameter, the other of duration of passage of horizontal diameter) will indicate a numerical value of correction to be applied to the assumed diameter; but the two numerical values will absolutely agree. But if the Sun's disk is not really circular, then it is impossible that the comparison of observed vertical diameters on the one hand, and of observed durations of passage of horizontal diameters on the other hand, with elements computed on the supposition that the Sun is circular, can indicate the same correction to the assumed semidiameter.

All that is necessary, therefore, for ascertaining whether the Sun's horizontal diameter and the Sun's vertical diameter are equal, is, every day to compare the Sun's observed vertical diameter with the *Nautical Almanac* diameter, and the observed duration of passage of Sun's horizontal diameter with the *Nautical Almanac* duration, and to infer separately from these the correction to be made to the *Nautical Almanac* assumed diameter. If the two results agree, the horizontal and vertical diameters are equal.

Now these comparisons are made every day in the routine of the Royal Observatory, and their results will be found in

1862MNRAS..22...80A

one of the late sections of each volume of the printed *Greenwich Observations*, as well as in the more extensively distributed *Results of the Greenwich Observations*, which contain that section; and the means of the numbers for each year are given in the Introduction to each volume. By extracting these numbers, the following table is formed. I have thought it necessary to divide the table into three parts, distinguished by the following circumstances:—From 1836 to 1850, the 4-inch telescope (I believe Dollond's) of the Mural-Circle was used for the vertical diameters, and the 5-inch telescope (Dollond's) of the Transit for the horizontal passages; the diameter used in the computations of the *Nautical Almanac* was 32′ 1″·80. Through 1851 and 1852, the 8-inch telescope (Simms') of the Transit-Circle was used for both measures, the *Nautical Almanac* assumed diameter being still 32′ 1″·80. From 1853 to 1860, the telescope of the transit-circle was used for both measures, but the *Nautical Almanac* assumed diameter was 32′ 3″·64.

Apparent Errors of the Duration of Passage of the Sun's Horizontal Diameter, and of the Sun's Vertical Diameter, as computed in the Nautical Almanac.

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A. — Ob.	No. of Obs. of Vertical Diameter.	Mean Value of N.A. — Ob.
		s		″
1836	104	−0·17	116	−1·50
1837	92	−0·18	122	−1·85
1838	108	−0·14	115	−1·53
1839	103	−0·14	114	−0·94
1840	104	−0·18	112	−1·60
1841	102	−0·14	109	−1·32
1842	116	−0·14	121	−1·54
1843	99	−0·14	107	−1·84
1844	102	−0·18	117	−1·50
1845	100	−0·17	113	−1·32
1846	92	−0·10	101	−2·09
1847	89	−0·05	89	−2·98
1848	94	−0·06	102	−2·06
1849	103	−0·11	101	−2·40
1850	94	−0·11	86	−2·18
1851	87	−0·08	106	−0·71
1852	103	−0·12	112	−1·39
1853	78	0·00	86	+0·58
1854	109	+0·09	111	+1·29
1855	84	+0·07	93	+0·65

1862MNRAS..22...80A

Year.	No. of Obs. of Horizontal Diameter.	Mean Value of N.A.—Ob.	No. of Obs. of Vertical Diameter.	Mean Value of N.A.—Ob.
		s		″
1856	104	+0·10	109	+1·17
1857	113	+0·07	123	+0·99
1858	126	+0·07	132	+0·92
1859	109	+0·08	125	+0·99
1860	72	+0·09	72	+1·64

If we take the sums of the numbers of observations and the means of the errors, and if we remark that the mean error of the horizontal diameter in arc may be obtained from the mean error of the duration of passage without sensible error by multiplying by 14, we obtain the following numbers:—

Period.	No. of Obs.	Mean Error of N.A. Duration of Passage.	Mean Error of N.A. Horizontal Diameter.	No. of Obs.	Mean Error of N.A. Vertical Diameter.
		s	″		″
1836 to 1850	1502	−0·134	−1·88	1625	−1·78
1851 and 1852	190	−0·100	−1·40	218	−1·05
1853 to 1860	795	+0·071	+0·99	851	+1·03

If we change the signs of these errors, to form corrections, and apply them to the assumed diameter at mean distance of the Earth from the Sun (namely, 32′ 1″·80 to the end of 1852, and 32′ 3″·64 from the beginning of 1853), to produce a corrected diameter of the Sun at mean distance, we form the following table:—

Instruments employed.	Period.	No. of Obs.	Corrected Horizontal Diameter.	No. of Obs.	Corrected Vertical Diameter.
			′ ″		′ ″
Transit and Mural Circle ...	1836 to 1850	1502	32 3·68	1625	32 3·58
Transit Circle ...	{1851 and 1852}	{190}	{32 3·20}	{218}	{22 2·85}
	{1853 to 1860}	{795}	{32 2·65}	{851}	{32 2·61}
	Mean 1851 to 1860	985	32 2·76	1069	32 2·66

Thus the observations with both classes of instruments, in aggregate number 2487 for horizontal diameter and 2694 for vertical diameter, agree in showing that the horizontal diameter exceeds the vertical diameter by only 0″·1, a quantity smaller than we can answer for in these or in any other methods of observation.

1862MNRAS..22...84A

A consideration of the number and excellence of the observations fully supports the view which I have stated in introducing this subject: that the only result which could be deduced from the trial of new apparatus would be to test the apparatus, but not to add to the certainty of the conclusion as to the equality of diameters.

The diameter adopted now in the *Nautical Almanac* was inferred from observations made with the Transit and Mural Circle, and therefore agrees very closely with that here deduced from the use of those instruments. That obtained with the Transit-Circle is less by 0″·93.

Royal Observatory, Greenwich,
Dec. 28*th*, 1861.

Table of Comparative Number of Observations of Small Planets. By the Astronomer Royal.

For my own guidance, in arranging the course of observations of the Royal Observatory, I lately thought it necessary to draw out a Table exhibiting the comparative number of observations of the Small Planets between *Mars* and *Jupiter*, on the one hand, as made at all Observatories (in the aggregate) except that of Greenwich, and on the other hand as made at Greenwich. For this purpose, I fixed upon the year 1858, as the latest for which I might presume all observations to be published; and my Assistant, Mr. Carpenter, examined every record to which I have access. The result may, perhaps, be interesting to the Society.

For Small Planets discovered before the middle of 1857.

Name of Planet.		Number of Observatories.	Number of Observations.		Observatory, Greenwich.	Number of Meridional Observations.
			Equatoreal.	Meridional.		
Ceres	①	2	0	21	”	22
Pallas	②	2	0	12	”	29
Juno	③	2	0	24	”	27
Vesta	④	3	0	24	”	31
Hebe	⑥	4	0	11	”	19
Iris	⑦	5	14	13	”	21
Flora	⑧	7	13	47	”	23